Formation of Birkeland current system in a weakly ionized Hall MHD dynamics

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Unified formulation for Birkeland current formation in a three-dimensional magnetosphere-ionosphere system is derived. In this formulation, ionosphere is not treated as the boundary condition for magnetospheric phenomena but also in a part of weakly ionized Hall MHD dynamics region. Therefore ionospheric polarization effects including Cowling channel are unified in a formation of Birkeland current system. Using this formulation, generalized wave equations for the three-dimensional magnetosphere- ionosphere coupling are derived. This formulation unifies two types of mode conversion between shear Alfven wave and compressional wave, that is, one by the inhomoginity of the Alfven velocity in the magnetosphere and the other by the multi-step inductive Hall effect in the ionosphere. Wave generation by the magnetospheric dynamo in the source region of the magnetosphere, by the atmospheric dynamo in the ionosphere and by the polarization effect in the loading region of the ionosphere can also be described by the same equation. The resultant horizontal propagation of ionospheric electrostatic potential field accompanied by the formation process of Birkeland current system could be explained by this formulation.